

PORTABLE AUTOMATIC TEST INSTRUMENT FOR VIDEO  
DISPLAYS AND GENERATORS

Field of the Invention

The present invention relates to the field of portable automatic test equipment for testing electronic video devices, and more particularly, to portable automatic test equipment for video displays and generators.

5 Background of the Invention

For thorough testing of video displays, video stimuli, ranging from simple to complex, multiple format video signals, are required. For the thorough testing of video generators, the real-time capture and analysis of complex video signals, for both format and image content, are required. For both display and generation testing, general purpose measurement  
10 capabilities including, but not limited to; voltage, resistance, frequency, time interval and waveform analysis (both time and frequency domain) are also required

Portable automatic test equipment for the testing of video devices is known. However, it is commonly required to evaluate the performance and functionality of application specific non-standard video displays. Specifically, the video displays may require special image and  
15 scan formats, voltage levels, and timing signals. In addition, fault simulation may be required to verify the functionality of the video display. For the evaluation of video generators, an apparatus for both displaying and analyzing video signals of any format is required. In a portable realization, size and weight are critical.

Objects and Summary of the Invention

20 It is an object of the present to provide a new and improved apparatus for portable testing of electronic video devices.

It is another object of the present invention to provide new and improved general-purpose test capability from a specialized device to maximize functionality while minimizing size and weight.

25 In order to achieve these objects and others, a portable automatic video device tester generally includes a programmable video generator and analyzer, a signal

conditioner/switching device, a command module, a portable computer (laptop) with an integral monitor and a portable VXI chassis. The command module, the computer and the VXI chassis may be commercial off the shelf components, with the command module being arranged in connection with the chassis. The programmable video generator and analyzer is  
5 arranged in connection with the chassis and adapted to be connected to one or more video devices being tested, i.e., it is possible to simultaneously test multiple video devices in accordance with the invention. The video generator and analyzer includes a generating mechanism for generating various forms of video test signals. The signal conditioner/switching device is also arranged in connection with the chassis and adapted to be  
10 connected to one or more of the video devices being tested. The computer communicates with the video generator and analyzer and the signal conditioner/switching device via the command module in order to conduct test operations and enable display of test results on the monitor.

The combination of the foregoing elements in a single automatic video testing device  
15 provides a complete and versatile portable tester encompassing both video and general-purpose capabilities. The programmable video generator and analyzer may be a VXI register based, single "C" size, instrument intended for use in automatic test equipment. It can also include two composite (raster) video generator functional groups, one stroke (XYZ) video generator functional group and one multi-video capture/redisplay functional group.

20 More specifically, the programmable video generator and analyzer may include a primary raster video generator for generating high-resolution bit-mapped images for cathode ray tube (analog) and flat panel (digital) displays, a secondary raster video generator and timer module for generating medium resolution bit-mapped images in multiple synchronized scan formats, and a stroke generator for generating stroke.

25 The programmable video generator and analyzer and its associated software are preferably designed to provide all video capabilities for both generation and capture/analysis. The signal conditioner/switching device may be a VXI register based, single "C" size, instrument intended for use in automatic test equipment. It may include four signal conditioning modules and two groups of switches. Each signal-conditioning module provides  
30 the necessary signal conditioning to enable the programmable video generator and analyzer to emulate a type of general-purpose instrument: digital multi-meter, counter/timer,

digitizer/oscilloscope and digital pulse generator. The two switching groups select between the video and general-purpose instrumentation.

#### Brief Description of the Drawings

The following drawings are illustrative of embodiments of the invention and are not  
5 meant to limit the scope of the invention as encompassed by the claims.

FIG. 1 is a schematic of a programmable video generator and analyzer for use in a portable automatic test instrument in accordance with the invention.

FIG. 2 is a schematic of a signal conditioning/switching device of an automatic test instrument in accordance with the invention and its connection to the video generator and  
10 analyzer shown in FIG. 1.

FIG. 3 is a schematic of a portable automatic test instrument in accordance with the invention.

FIG. 4A is a schematic showing the route between the video source and the video display in an operational, i.e. non-test, mode.

FIG. 4B is a schematic showing the route between the video source, the portable  
15 automatic test instrument and the video display in a test mode.

#### Detailed Description of the Preferred Embodiments

Referring to the accompanying drawings wherein the same reference numerals refer to the same or similar elements, a portable automatic video test analyzer in accordance with the  
20 invention is generally designated as 10 and generally includes a Programmable Video Generator and Analyzer (PVGA) 12, such as of the type disclosed in the current assignee's U.S. Pat. No. 6,396,536, incorporated by reference herein in its entirety (shown in FIG. 1), a Signal Conditioner/Switching Device (SC/SD) 14 (shown in FIG. 2), a COTS command module 16, a COTS portable computer (laptop) 18 with an integral monitor 20 and a COTS  
25 portable VXI chassis 22 (see FIG. 3).

The computer 18 conducts all test operations and displays the results on its integral monitor 20. The computer 18 is coupled to and communicates with the PVGA 12 and the SC/SD 14 through the Command Module 16. All signals to and from a Unit Under Test 24, both stimulus and response signals, are routed to/from the PVGA 12 either directly or via the  
30 SC/SD 14. Signals are also exchanged between the PVGA 12 and the SC/SD 14 via a signal

coupling. The VXI chassis 22 provides the necessary system interconnect, power conditioning, cooling and housing functions.

The automatic video test analyzer 10 provides a complete and versatile portable video tester by utilizing the attributes of its components, namely, the attributes of the PVGA 12, the SC/SD 14 and the portable computer 18 with its integral monitor 20. In particular, the automatic video test analyzer 10 utilizes the video specific capabilities of the PVGA 12, the general-purpose test capabilities of the PVGA 12 as augmented by ancillary hardware of the SC/SD 14, or other stand-alone VXI instruments, and the capability to redisplay any video images on the monitor 20 of the portable computer 18.

The following description explains the operation of an exemplifying embodiment of the automatic video test analyzer 10 in accordance with the invention as it functions to test video signals.

#### A. Video Testing - Generation

All video generation by the automatic video test analyzer 10 is handled directly by the PVGA 12. With reference to FIG. 1, the PVGA 12 has three modules that produce video in various forms, namely a Primary Raster Video Generator (PRVG) 26, a Secondary Raster Video Generator and Timer Module (SRVG/TM) 28 and a Stroke Video Generator (SVG) 30. The three generation modules (PRVG 26, SRVG/TM 28 and SVG 30) of the PVGA 12 are controlled by the portable computer 18 via a VXI Interface Module (VIM) 32. The time base, or clock, for each module is supplied by the Distributed Time Base (DTB) 34 which can also connect any of the modules to an external clock.

The Primary Raster Video (PRVG) 26 generates high-resolution bit-mapped images for cathode ray tube (analog) and flat panel (digital) displays. Standard and non-standard scan formats, both synchronized and deflection driven, are directly supported by the PRVG 26. An internal dedicated drawing engine greatly accelerates the loading of the image into the bit map. A dynamic overlay image may be superimposed on the main image. The dynamic overlay can be updated from frame to frame as to content, position, or foreground/background status. In addition, the overlay can be modulated (on/off) by an external digital signal provided by the VXI interface module 32. For Units Under Test 24 that require direct analog raster scan deflection waveforms, the PRVG 26 is designed to provide these in multiple formats.

The Secondary Raster Video Generator and Timer Module (SRVG/TM) 28 generates medium resolution bit-mapped images in any synchronized scan format. The purpose of the SRVG/TM 28 is to produce a second video signal of either identical or different format than that of the PRVG 26. The two video signals, one from the PRVG 26 and another from the SRVG/TM 28, can be used together to test multi-scan monitors, video switching systems, channel isolation and the like, or separately to simultaneously test multiple displays. The Timer Module portion of the SRVG/TM 28 provides a mechanism for measuring time intervals (either one-shot or cumulative) or frequency. The Timer Module portion of the SRVG/TM 28 also produces programmable digital patterns (Digital Out) that may be buffered and routed to the digital connector of the PVGA 26.

The Stroke Generator (SVG) 30 produces stroke, or X-Y-Z video in which the image is drawn on the screen by directly deflecting the beam along the lines of the image being drawn. Complex, interactive images can be produced by the SVG 30 by means of its programmable sequence control structure that controls the order, duration, and position of image elements. Image control can be a mix of internal, external, or real time software.

Associated with each of the above modules, i.e., the PRVG 26, the SRVG/TM 28 and the SVG 30, are a set of output channels 36, 38, 40, respectively, three low voltage channels (Red, Green, Blue) for the PRVG 26, three low voltage channels (Red, Green, Blue) for the SRVG/TM 28 and three high voltage channels (X, Y, Z) for the SVG 30. All of these output channels is aligned at run time by means of a Voltage Sense Module (VSM) 42 controlled by the computer 18 via the VXI interface module 32.

The VSM 42 is a multi-channel high accuracy differential voltage sense circuit with an integral voltage reference source. The VSM 42 can sense the voltage at all relevant points on the sets of output channels 36, 38, 40. The host computer 18 reads the voltage at these points and calculates the transfer characteristics of the channel being aligned. The sets of output channels 36, 38, 40 utilize digitally controlled gain and offset circuits to set each channel's operational parameters.

To achieve the desired characteristics, an output alignment software driver resident in the host computer 18 compares the sensed transfer characteristics with the specified transfer characteristics, calculates the necessary corrections, and writes them to the output channel being aligned. This arrangement permits the channels to be aligned at the time of use to

parameters called for in the test program set (TPS) program. Since the channels are accurately aligned at run time, essentially all long term drift errors are eliminated.

For greater accuracy, the VSM 42 provides a remote sense capability so that the output voltages are sensed directly at the inputs of the Unit Under Test 24, thus eliminating the effect of cable losses and ground offsets.

#### B. Video Testing - Capture

All video generation is handled direct by a video capture module 44 of the PVGA 12 (see FIG. 4B). The Video Capture Module (VCM) 44 performs one-shot full frame video image capture on both analog and digital video in either synchronized or deflection driven format. For synchronized video, the VCM 44 has an adaptive sync lock that locks on the input synchronization signal even if the signal is marginal. The VCM 44 can acquire images without restriction as to frame/line rate, voltage levels or sync format. The VCM 44 is controlled by the portable computer 18 via the VXI Interface Module (VIM) 32. The time base, or clock, for the VCM 44 is supplied by the Distributed Time Base (DTB) 34 which can also connect any of the modules to an external clock.

Once an image from the video source 46 is acquired by the video capture module 44, the image can be immediately redisplayed via a Redisplay Software Tool 48 onto the monitor 20 of the host computer 18 (see FIG. 4B).

The VCM 44 can capture video signal in several modes with differing data widths and rates as follows:

1. Three channel operation - for color synchronized video (red, green and blue) and stroke video (X axis deflection, Y axis deflection and Z axis intensity) or deflection driven video (horizontal deflection, vertical deflection and intensity) at 12 bits resolution up to 20 MHz or 8 bits resolution up to 40 MHz. To capture stroke video or deflection driven video, the two deflections, X (horizontal) and Y (vertical), and the intensity Z, are sampled and stored concurrently. The hardware of the VCM 44 will reassemble the captured image by using the X and Y deflection samples as orthogonal vectors into its memory space and the intensity Z samples as the data.

2. Single channel operation - for monochrome video or one of the three channel type signal above at 12 resolution up to 40 MHz or 8 bits resolution up to 80 MHz.

The VCM 44 accepts externally applied triggers and gates. In the gate mode, video capture will begin when the externally applied is asserted and video capture will halt when the gate is de-asserted. Gate mode is intended for use with stroke capture when the VCM 44 is free-running during the capture interval. For synchronized video, the trigger mode allows the user to select which full frame of video is captured. When the trigger is asserted, the VCM 44 will halt at the end of the current frame.

The VCM 44 has three input channels that have digitally controlled gain and offset. As with the output channels discussed above, the input channels are aligned at run time via the VSM 44 and an input alignment software driver.

### C. Video Testing - Example

FIGS. 4A and 4B show a typical application of the automatic video test analyzer 10 for remote video testing. As shown, a video source 46 drives a video display 50. To effectively fault-detect and isolate, it is necessary to both analyze the output of the video source 46 and drive the video display 50 with appropriate test images. FIG. 4B shows how this is effectively accomplished.

First, the VCM 44 captures the video from the video source 46 under test. Once captured, the Redisplay Software Tool 48 uploads the formatted image from the PVGA 12 and transfers it to the monitor 20 of the computer 18. The Redisplay Software Tool 48 provides a set of analysis tools such as overlaying of oscilloscope-like grids, automatic determination of pixel location, detailed waveform analysis and measurement of sync/blanking/active video patterns for each line, and the like.

An important aspect of this method is that no external monitor or display device is required to analyze any video image, i.e., the computer's integral monitor 20 is sufficient for all video testing.

In addition to capturing and analyzing the output of the video source 46, the automatic video test analyzer 10 will also generate whatever video test image is required to fully exercise the display under test (i.e., the video display 50). The inherent flexibility of the generation capability of the PVGA 12 allows it to test any display. Non-standard video is produced as readily as standard format video. If necessary for complete testing or fault isolation, deliberately corrupted video can be generated.

#### D. General Purpose Testing

A combination of the PVGA 12 and dedicated modules of the SC/SD 14 realize all general-purpose instrumentation. The modules of the SC/SD 14 include a Digital Multi-Meter Emulator (DME) 52, a Counter/Timer Emulator (CTE) 54, a Digitizer/Oscilloscope Emulator (DOE) 56 and a Pulse Generator Buffer (PGB) 58.

The DME 52 works in conjunction with a remote sense port 60 of the VSM 42. Since the remote sensing ports 60 of the VSM 42 represent high impedance, accurate DC measurement assets, all that is required to fully emulate a DME 52 is scaling and signal conditioning. The DME 52 provides both.

The VSM remote sense port 60 has a voltage range of  $\pm 10$  VDC. The DME 52 will include attenuation and amplification to extend the voltage range of the VSM 42 to whatever values are required. An attenuation of 10:1 increases the full accuracy range to  $\pm 100$  VDC, an amplification of 10 yields a full accuracy range of  $\pm 1$  VDC, and so on. Once the input voltage has been scaled to  $\pm 10$  VDC range of the VSM 42, further conditioning is available.

An AC to RMS converter extends the capability of the emulated DME 52 to cover AC voltages. A voltage-limited programmable current source applied to the input when reading DC voltage will produce accurate resistance measurements.

Associated with the DME 52 is a group of switches 62 that will connect the remote ports of the VSM 42 either to the DME 52 for voltage and resistance measurements or directly to the video inputs of the Unit Under Test 24 for optimal output alignment as discussed above.

With respect to the Counter/Timer Emulator (CTE) 54, in order to realize counter/timer functions in the automatic video test analyzer 10, the Timer Module portion of the SRVG/TM 28 will serve as the measurement asset and the CTE 54 will provide the necessary signal conditioning.

An optimal path to the SRVG/TM 28 is via the externally applied PVGA clocks. Clock generation and distribution is the function of the Distributed Time Base (DTB) 34, a module in the PVGA 12 (see FIG. 1.). The DTB 34 contains four high-resolution frequency synthesizers. The synthesizers are individually dedicated to the PRVG 26, SRVG/TM 28, SVG 30 and VCM 44. This allows each module of the PVGA 12 to have an independent

clock frequency and also permits fully synchronous operation due to the common reference oscillator.

The DTB 34 can also buffer, level shift and route external clocks to each module. The external clocks of the PVGA 12 may be differential PECL.

5       The CTE 54 will translate the input level to differential PECL. A programmable high-speed comparator, configurable as either single-ended or differential, will sample the input signal at a user specified threshold voltage and convert the resulting signal to differential PECL. Prescaling in the CTE 54 will extend the frequency measurement range of the Timer Module portion of the SRVG/TM 28 to whatever range is required. A programmable divider  
10 will extend the range of the Timer Module for time interval measurement.

The Digitizer/Oscilloscope Emulator (DOE) 56 works in conjunction with the VCM 44 of the PVGA 12. In order to use the capabilities of the VCM 44 for a general waveform capture and display application, external gate and triggers must be derived from the input signal. To emulate a typical oscilloscope, the input signal will be compared with a user-specified  
15 threshold and polarity. When the input reaches the specified state, the DOE 56 will generate a gate pulse. The VCM 44 will be setup for a gated, free running mode, the same as for stroke capture.

The user specified duration of the gate pulse, with an appropriate sampling rate of the VCM 44, determines the length of the sample and is therefore analogous to the time/division  
20 setting on an oscilloscope. The user-specified delay between the threshold comparison and the start of the gate corresponds to the delayed trigger function on an oscilloscope. Immediately upon completion of the sampling, the Redisplay Software Tool 48 displays the captured waveform along with appropriate grids and legends on the computer integral monitor.

The Pulse Generator Buffer (PGB) 58 works in conjunction with the SRVG/TM 28 of  
25 the PVGA 12. The Timer Module portion of the SRVG/TM 28 can produce a wide range of clock signals based on either its local fixed oscillator or the programmable clock from the DTB 34. In addition, the video portion of the SRVG/TM 28 can produce arbitrary complex digital patterns. These digital signals may be in TTL form. The PGB 58 in the SC/SD 14 will accept the TTL level inputs and level shift them to user-specified voltages. The output buffer  
30 will provide high current output drive and impedance matching.

The basic structure of the automatic video test analyzer 10 described above can be readily modified to suit any given set of requirements. If additional functionality or greater accuracy is required, one can augment the PVGA 12 and SC/SD 14 with one or more COTS VXI instruments residing in either the same or a separate chassis.

5        While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.